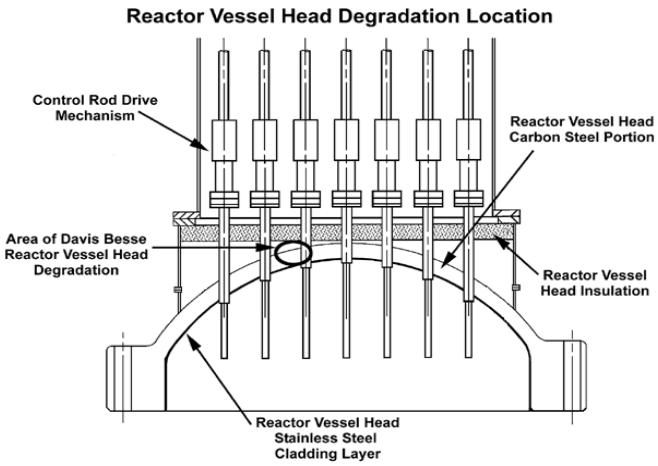
Davis-Besse Reactor Vessel Head Damage
NRC UPDATE

September 2002

This is the first of a series of periodic updates on the NRC response to the reactor vessel head damage at the Davis-Besse Nuclear Power Station. The updates will be available at public meetings of the NRC Davis-Besse Oversight Panel which is coordinating the agency's activities related to the damage. Each issue will include background information to assist the reader in understanding issues associated with the corrosion damage.

What Happened at Davis-Besse



In March 2002 plant workers discovered a cavity in the head or top of the reactor vessel while they were repairing control rod tubes which pass through the head.

The tubes which pass through the reactor vessel head are called control rod drive mechanism nozzles. Cracks were detected in 5 of the 69 nozzles. In three of those nozzles, the cracks were all the way through the nozzle, allowing leakage of reactor cooling water, which contains boric acid.

Corrosion, caused by the boric acid, damaged the vessel head next to Nozzle No. 3, creating an irregular cavity about 4 inches by 5 inches and approximately 6 inches deep. The cavity penetrated the carbon steel portion of the vessel head, leaving only the stainless steel lining. The liner thickness varies somewhat with a minimum design thickness of 1/8 inch.

Earlier indications of the problem: Through-Wall Cracking of Nozzles in France and at the Oconee Nuclear Power Station in South Carolina

In the early 1990's control rod drive mechanism nozzle cracking was discovered at a nuclear plant in France. These cracks penetrated the nozzle wall along the length of the nozzle (referred to as 'axial' cracking). In 1997 the NRC issued Generic Letter 97-01 to gather information on the inspection activities for possible cracking in the control rod drive mechanism nozzles in plants in the United States. Subsequently, through-wall circumferential cracks -- around the nozzle wall -- were discovered in two control rod drive mechanism nozzles at the Oconee Nuclear Power Station, Unit 3, in 2001. While axial cracking had been found at several other plants and repaired, circumferential cracking had not been seen before. Circumferential cracking is more significant because it could lead to complete separation of the nozzle and a resulting loss of coolant accident.

After the Oconee discovery, the NRC issued Bulletin 2001-01, requiring all pressurized water reactor (PWR) operators to report to the NRC on structural integrity of the nozzles, including the extent of any nozzle cracking and leakage and their plans to ensure that future inspections would guarantee structural integrity of the reactor vessel boundary. The NRC's Bulletin instructed nuclear power plants with similar operating history to Oconee Unit 3, including Davis-Besse, to inspect their reactor vessel head penetrations by December 31, 2001, or to provide a basis for concluding that there were no cracked and leaking nozzles.

FirstEnergy Nuclear Operating Company requested an extension of the inspection deadline until its refueling outage beginning March 30, 2002, and provided the technical basis for its request. The NRC did not allow the plant to operate until March 30, but agreed to permit operation until February 16, provided that compensatory

measures were taken to minimize possible crack growth during the time of operation. The NRC was unaware that nozzle leakage or corrosion had occurred at Davis-Besse when it agreed to the February 16 date.

Boric Acid Corrosion Control Procedure

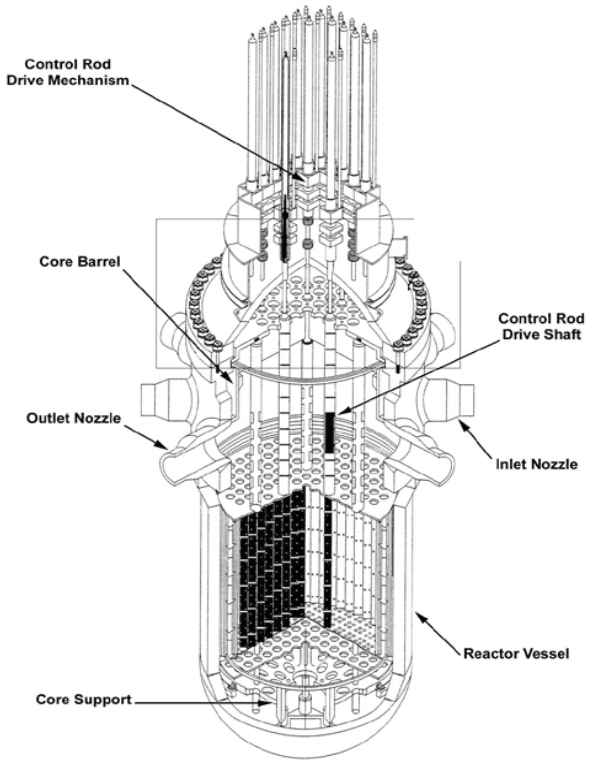
The water that circulates through a pressurized water reactor to cool the nuclear fuel contains a low concentration of boric acid. This borated water can potentially leak through flanges, pump and valve seals, and other parts of the reactor cooling system and cause corrosion, especially if the boric acid becomes a concentrated liquid.

The NRC has taken steps to make sure that PWR operators are aware of and pay attention to the corrosion boric acid can cause in certain environments:

- In 1986-89, the NRC issued a series of documents, called "generic communications," informing PWR licensees that boric acid can corrode and damage steel reactor components.

- The NRC's Generic Letter 88-05 requested PWR operators to implement a program to ensure that boric accid corrosion does not lead to degradation of the reactor cooling system components. All nuclear power plants with PWRs, including Davis-Besse, reported to NRC that the Boric Acid Control Procedures had been established and would be implemented.

Typical Pressurized Water Reactor



Barriers Built into Nuclear Plants to Protect Public Health and Safety

The design of every nuclear power plant includes a system of three barriers which separate the highly radioactive material in the reactor fuel from the public and the environment. The Davis-Besse reactor head damage represented a significant reduction in the safety margin of one of these barriers, the reactor coolant system. The reactor coolant system, however, remained intact, as well as the other two barriers, the fuel and the containment.

1. Fuel Pellets and Rods

The first barrier is the fuel itself. The fuel consists of strong, temperature-resistant ceramic pellets made of uranium-oxide. The pellets are about the size of a little finger-tip. They retain almost all of the highly radioactive products of the fission process within their structure.

The pellets are stacked in a rod-shape with metal cladding made of a zirconium alloy. At Davis-Besse, each fuel rod is about 13 feet long. The rods are assembled and held into bundles, with each assembly containing 208 rods. The entire reactor core contains 177 fuel assemblies. Any fission products which escape from the pellets are captured inside the cladding of the rod, which is designed to be leak-tight. The operating license contains limits on the maximum allowable amount of leakage of radioactive materials from the fuel rods, and it specifies requirements for leakage monitoring.

2. Reactor Coolant System

The second barrier is the reactor coolant system pressure boundary. The reactor core is contained inside the reactor pressure vessel, which is a large steel container. Thick steel pipes supply cooling water to the reactor,

and carry away the heated water after it passes through the reactor core. The pressure vessel, the connected piping, and other connected components make up the reactor coolant system pressure boundary. At Davis-Besse, the reactor coolant system contains about 60,000 gallons of cooling water, circulated by four very large pumps at a rate of about 360,000 gallons per minute.

This system is designed to be leak-tight at operating conditions which include a water temperature of 605° F and a water pressure of 2,150 pounds per square inch. The operating license contains limits on the maximum allowable amount of leakage from the system, and it specifies requirements for monitoring the leak rate. If a leak is identified as being through any solid wall of the system (reactor vessel, cooling pipes or other components) continued operation of the plant is prohibited, no matter how small the leak rate.

3. Containment Building

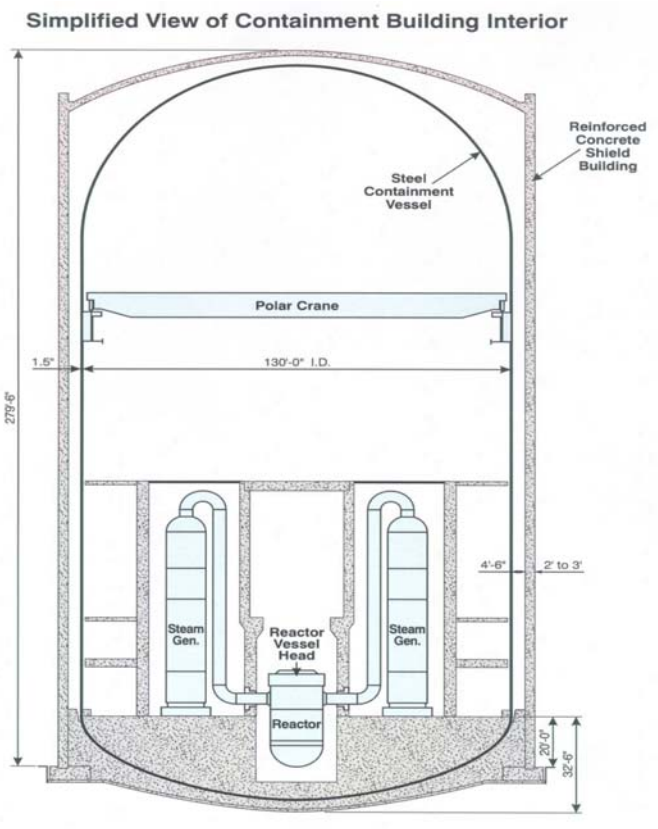
The third barrier is the containment building. This is a large cylindrical building which contains the entire reactor coolant system. None of the piping that contains the high-temperature and high-pressure reactor coolant water extends outside the containment building. The containment is a 1 1/2 inch thick steel cylinder, rounded at the top and bottom, which is designed to be leak-tight. This steel structure is surrounded by a reinforced concrete shield building, which is the round building visible from the outside of the plant.

NRC's Response to Vessel Head Damage

The NRC responded to the vessel head degradation with a series of actions, some specific to Davis-Besse and others aimed at other PWR operators. The agency began a review of its regulatory activities as well.

Davis-Besse

On March 12, 2002, the NRC initiated an Augmented Inspection Team to examine conditions that led to the head degradation and on March 13, 2002, the NRC issued a Confirmatory Action Letter to Davis-Besse documenting a number of actions the plant needed to implement for the unit to be allowed to restart. On April 29, 2002, the NRC established an Oversight Panel under the Agency's Manual Chapter 0350, to coordinate and oversee NRC activities necessary to address repairs and performance deficiencies at the plant in order to guarantee that it can operate safely. The plant will not restart until the NRC is satisfied that plant operators have met all necessary safety requirements.



Generic

On March 18, 2002, the NRC issued Bulletin 2002-01, instructing PWR licensees to report on the condition of their head, past incidents of boric acid leakage and the basis for concluding that their boric acid inspection programs were effective. All plants sent their responses and indicated that no evidence of extensive corrosion of reactor vessel heads was found at these plants. On August 9, 2002, the NRC issued Bulletin 2002-02 advising PWR operators that more stringent inspection techniques may be were necessary to detect head penetration nozzle cracks. Visual examination of reactor vessel heads and nozzles may need to be supplemented with other inspection techniques, such as the use of ultrasound, electric currents and liquid dyes.

NRC Performance

The NRC established a Lessons Learned Task Force to conduct an independent evaluation of the NRC staff's regulatory processes related to assuring reactor vessel head integrity in order to identify and recommend areas of improvement applicable to the NRC and/or the industry. The scope of the task force effort includes: reactor oversight process issues, regulatory process issues, research activities, applicable practices used in the international community, and the NRC's generic issue process. The task force is headed by Art Howell, a senior manager from the Region IV Office, and includes NRC personnel who have not previously been directly involved with regulatory activities for the Davis-Besse plant. The results of the review will be made public.

Reactor Oversight Process

The NRC uses the Reactor Oversight Process to ensure public health and safety in the operation of commercial nuclear power plants. This process uses a variety of inspectors to monitor plant activities, including NRC resident inspectors who work at the plant every day and live near the plant, and inspectors from regional and headquarters offices. The inspection program focuses on activities and systems that are “risk significant,” meaning those activities and systems that could trigger or increase the consequences of an accident, and those required to function to mitigate the consequences of an accident. The inspection program includes baseline inspections common to all plants and supplemental inspections which focus on issues of heightened safety significance. The inspection program is selective with inspectors reviewing a sample of risk significant plant operating activities. The plant operator is obligated to adhere to all safety requirements, maintain accurate records, and report to the NRC on safety significant aspects of plant operations.

NRC’s Davis-Besse Oversight Panel

An NRC Davis-Besse Oversight Panel was created to make sure that all corrective actions, required to ensure that Davis-Besse can operate safely, are taken before the plant is permitted to restart and that Davis-Besse maintains high safety and security standards if it resumes operations. Should the plant restart, the Oversight Panel will evaluate if Davis-Besse’s performance warrants reduction of the NRC’s heightened oversight and, if so, recommend to NRC management that the plant return to a regular inspection schedule. The panel was established under the agency’s Manual Chapter 0350 and thus is often referred to as the “0350 panel.”

The panel brings together NRC management personnel and staff from the Region III office in Lisle, Illinois, the NRC Headquarters office in Rockville, Maryland and the NRC Resident Inspector Office at the Davis-Besse site. The eight-member panel’s chair and co-chair are John Grobe, a senior manager from Region III and William Dean, a senior manager from NRC headquarters.

As part of determining if plant corrective actions are adequate to support restart, the Oversight Panel will evaluate FirstEnergy's return to service plan, which is divided into seven areas of performance that the utility calls "building blocks." A series of NRC inspections will be performed to verify the company is taking proper actions in each of the seven areas. These reviews will include the work by the FirstEnergy staff and, in addition, the NRC staff will perform independent inspections in each of the "building block" areas.

The Oversight Panel has established a Communications Plan and a Communications Team to ensure the activities of the NRC and those of FENOC/Davis-Besse are made known to interested members of the public. This newsletter is one means of sharing information. In addition, a schedule of regular meetings with FirstEnergy managers and with the public has been established. The two most recent meetings were on July 16 and on August 15, 2002. These meetings were transcribed and the transcripts posted with other meeting information on the NRC web page - http://www.nrc.gov - select the Davis-Besse link under ‘Key Topics.’

Current 0350 Oversight Panel Activities

Since the 0350 Oversight Panel public meeting on August 20, the NRC has completed the following:

- Continued to monitor activities associated with the reactor vessel head replacement process, including removal of the old, damaged head and inspecting the new replacement head from the canceled Midland (MI) nuclear plant.

- The NRC authorized a series of inspections of the corroded vessel head to better understand the mechanisms that led to the corrosion of the reactor vessel head and to investigate the condition of head materials through microscopic, chemical and other types of analysis. These inspections are conducted by Framatome in Lynchburg, Virginia. As a result of initial inspections of the portion of the vessel head containing the corrosion cavity, Framatome reported that the remaining stainless steel liner was thinner at some points that previously known and that a crack, about 3/8 inches long with some additional adjacent cracking, was identified in the surface of the liner. Framatome is conducting further analysis to characterize the cracking phenomenon.

- Completed the Augmented Inspection Team (AIT) follow-up inspection, which focused on identifying violations of NRC regulatory requirements in the root causes of the vessel head degradation at Davis-Besse detailed by the initial AIT inspection. The AIT follow-up inspection identified a number of apparent violations in Davis-Besse procedure adequacy, adherence to procedures, implementation of the corrective action and boric acid corrosion management programs, maintenance of complete and accurate records, submission of complete and accurate information to the NRC, and maintenance of the reactor coolant system pressure boundary. This inspection report is expected to be available in late September.

- Performed the Containment Walk-Down Inspection, Part I, which confirmed that many of the inspection activities were well performed. The NRC inspectors, however, also found deficiencies in the training and qualification of some utility personnel performing the detailed walk-down inspections and in the adequacy of some inspections. As a result of these deficiencies, First Energy retrained its inspectors and is reperforming the inspections. The inspection report will be available in mid September. The second part of the Containment Walk-Down Inspection is underway.

Upcoming 0350 Oversight Panel Activities

Some of the NRC's oversight panel activities in the next six weeks will be the following:

- Continue to monitor activities associated with head replacement.

- Meet September 18, 2002, with FirstEnergy to discuss the planned corrective actions to address the Davis-Besse organizational and human performance problems presented to the NRC during the August 15, 2002, public meeting.

- Continue the Management and Human Performance Inspection, which will evaluate FirstEnergy's root cause analysis associated with management, organizational effectiveness and human performance factors that are believed to have led to the degradation of the reactor head. In addition, the inspection will focus on reviewing the licensee's efforts towards creating a more safety-focused environment and management at the Davis-Besse plant. This inspection will be performed in three phases over the next few months.

- Continue Part 2 of the Containment Walk-Down Inspection.

- Continue the Program Effectiveness Inspection, which is reviewing the plant's progress in creating more effective programs for such areas as corrective actions, boric acid corrosion control, modification control and others. This inspection will occur over several weeks in September and October.

- Start a Systems Health inspection which will review the plant's assessment of the impact on other important plant systems of the root causes which allowed the reactor head degradation to occur. The inspection will assess the adequacy of the FirstEnergy work and also include an independent NRC system adequacy evaluation conducted by the NRC staff and contractors. The inspections will occur over several weeks during September and October.

Issues to be resolved in order for Davis-Besse to restart

The 0350 Oversight Panel will only consider recommending that Davis-Besse resume operations when the plant has demonstrated its readiness to operate safely. Key elements will include:

- Davis-Besse management and personnel properly understand the technical, organizational, programmatic and human performance problems that led to the extensive degradation of the plant's reactor vessel head.

- Davis-Besse enhances programs for operating the plant safely, detecting and correcting problems, controlling boric acid corrosion, and is fostering a more safety-conscious environment among plant managers and workers.

- Davis-Besse improves the performance standards of its managers and workers, including their "ownership" of the quality of work products and the safety focus of decision-making.

- The replacement of the vessel head is technically sound and all reactor components are inspected, repaired as necessary, and demonstrated to be ready for safe operation.

- Plant safety systems inside and outside containment are inspected, repaired as necessary, and have been confirmed to be ready to resume safe operation of the plant.

- Plant operators demonstrate appropriate safety focus and readiness to restart the plant.

- Any organizational or human performance issues resulting from the ongoing investigation conducted by the NRC's Office of Investigations are addressed.

- All licensing issues that have arisen as a result of the reactor head replacement have been resolved.

What Happens If the Plant is Allowed to Restart

If the facility is permitted to restart, the 0350 Oversight Panel will continue to monitor plant activities and operations until panel members are confident that the root cause(s) of the problem have not recurred. Should FirstEnergy achieve that performance level, the 0350 Oversight Panel would recommend to NRC management that responsibility for the plant oversight be transferred back to the Region III line organization for monitoring under the Reactor Oversight Process. The panel would then cease to exist. Should FirstEnergy not demonstrate sustained improved performance, the panel will recommend appropriate regulatory actions.

Public Participation in the Process

The NRC's experience is that members of the public, including public officials and citizens, often raise questions or provide insights that are important to consider. If you have questions or want to provide information or a point of view, please contact us. For feedback on this newsletter, contact Viktoria Mitlyng 630/829-9662 or Jan Strasma 630/829-9663 (toll free 800/522-3025 - ext -9662 or -9663). E-mail: opa3@nrc.gov. Extensive information about the Davis-Besse reactor vessel head damage and the ensuing activities is available on the NRC web site: http://www.nrc.gov - select "Davis-Besse" under the list of key topics.